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A Radio Study of 13 Powerful FRII Radio Galaxies

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Abstract. We have observed a sample of 13 large, powerful Fanaroff-Riley type II radio galaxies with the Very Large Array (VLA) in multiple configurations and at multiple frequencies. We have combined our measurements of spectral indices, rotation measures and structural parameters such as arm-length ratios, axial ratios and misalignment angles, with similar data from the literature and revisited some well-known radio galaxy correlations.

1. The Radio Galaxy Sample

In order to do a spectral aging analysis in the radio bridges of Fanaroff-Riley-II (FRII) radio galaxies, we have observed a sample of 13 large, powerful FRII radio galaxies with the VLA using multiple configurations at 330 MHz, 1.4, 5 and 8 GHz (Kharb et al. 2006). The sources span the redshift range of $0.4 < z < 1.6$ and have angular extents $> 27''$. Using a large combined dataset comprising our radio galaxies and others from the literature we have revisited some well known radio galaxy correlations, the results of which are presented here.

2. Results

Using the combined radio galaxy dataset we confirm that the hotspot size r_h is correlated with the total linear size l of the source and follows the relation $r_h \propto l^{0.7}$. This result is consistent with a self-similar model of a jet (eg., Carvalho & O'Dea 2002) propagating in a medium where the ambient density ρ_a falls off with distance from source d as $\rho_a \propto d^{-0.2}$. This could be due to the large jets spanning hundreds of kiloparsecs in these sources, propagating mostly through a roughly constant density intergalactic medium. The hotspot spectral index is found to correlate with redshift and follows the relation, $\alpha_{HS} \propto z^{0.4}$, which is consistent with previous studies on radio galaxies (eg., Wellman et al. 1997).

The mean rotation measure (RM) of the radio lobes of the combined sample is correlated with Galactic Latitude. The rotation measure dispersion, on the other hand, is not. This suggests that the RM dispersion is probably caused by the source and/or its environment. We examined the Liu-Pooley correlation of lobe depolarization and spectral index, with the combined dataset, and found that the correlation is significant at the 99.99% significance level (Spearman rank test; Fig.1 Left). This is an improvement from the original radio galaxy correlation (excluding quasars) which was observed at the 80% significance level. Liu & Pooley (1991) had concluded that differences in the medium surrounding the two radio lobes influence both the spectrum and the depolarization. A denser

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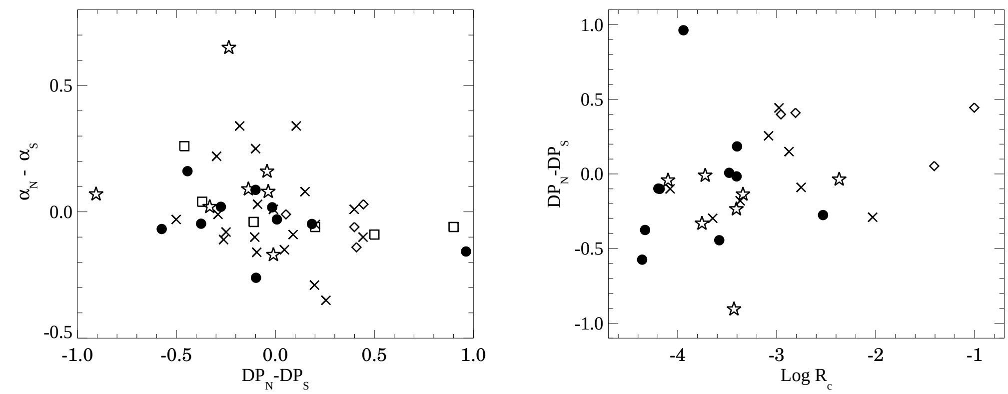

Figure 1. The North-to-South-lobe depolarization (DP) difference versus (Left) the difference in lobe spectral index (between 1.4 & 5 GHz), and (Right) the K-corrected radio core prominence (R_c). DP is the ratio of the fractional polarization in the lobe at 1.4 to 5 GHz; R_c is the ratio of the radio core to lobe flux density. Filled circles, stars, crosses, squares, and diamonds denote radio galaxies from Kharb et al. (2006); Liu & Pooley (1991); Goodlet et al. (2004); Pedelty et al. (1989) and Garrington et al. (1991), respectively.

medium around one radio lobe would result in greater confinement of the lobe, thereby decreasing the expansion losses and increasing the radiative losses, resulting in a steeper spectral index and greater depolarization. McCarthy et al. (1991) have indeed demonstrated that the emission-line gas is intrinsically asymmetric in powerful radio sources. However, we find that the depolarization does not seem to be correlated with the arm-length ratio or misalignment angle.

We find a weak correlation between lobe depolarization and radio core prominence - which is a statistical indicator of beaming and therefore orientation (Fig.1 Right). The weak correlation is consistent with the picture of these radio galaxies lying largely in the plane of the sky. The lobe-to-lobe differences in spectral index however, do not correlate with the arm-length ratios, misalignment angles or radio core prominence. Further, the arm-length ratios seem to be correlated with the misalignment angles but anti-correlated with the axial ratios. This is suggestive of environmental asymmetries close to the radio sources. Such asymmetries can cause a variation in the outflow direction which can result in larger misalignments between the two sides of the source. Variation in the jet direction can also result in fatter radio lobes and lower axial ratios.

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